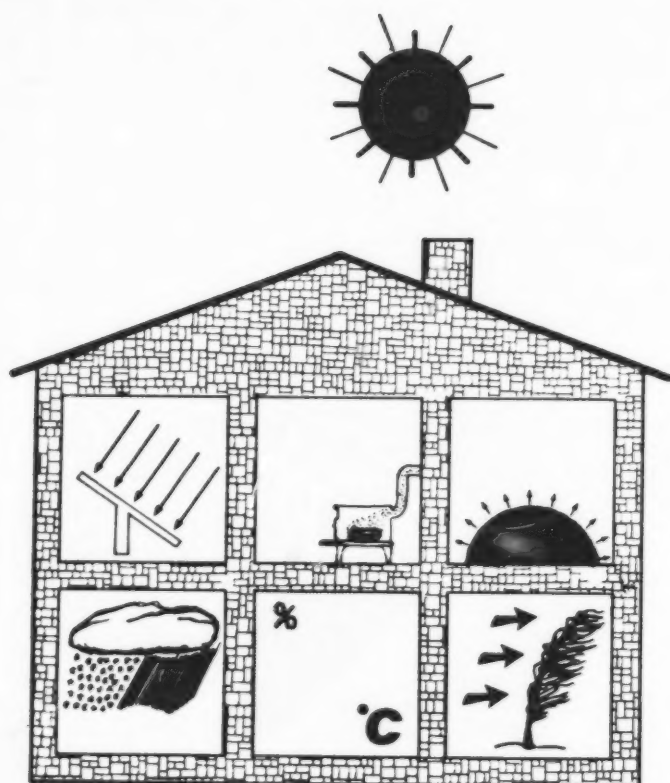




Canada Mortgage
and Housing Corporation

Société canadienne
d'hypothèques et de logement

CANADIAN ECOCHARTS: **Climatic Statistics Affecting Active and** **Passive Solar Housing and** **Environmentally Sensitive Planning**



Canada

CANADIAN ECOCHARTS:

CLIMATIC STATISTICS AFFECTING ACTIVE AND PASSIVE

SOLAR HOUSING AND ENVIRONMENTALLY SENSITIVE PLANNING

PREPARED FOR:

**CANADA MORTGAGE AND HOUSING CORPORATION
TECHNICAL RESEARCH DIVISION
OTTAWA**

BY:

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INTRODUCTION

This document has been published as an aid to climate-conscious designers, planners, and builders of solar and environmentally sensitive housing. The various climatic and solar data that affects housing are identified to facilitate innovative and cost-saving design practices.

This book is comprised of the Ecochart section and an accompanying explanatory guide. The Ecocharts provide monthly recorded meso-climatic and calculated solar data, for fifteen cities across Canada. The explanatory guide gives definitions, diagrams, deriving formulae, and examples where possible for each data category. It is advisable to read the guide in order to best understand the Ecochart data. All climatic measurements are recorded in metric units.

Data values can be obtained for locations other than the fifteen cities provided in the Ecocharts. Climatic data is available from various volumes of Climatic Normals published by Environment Canada (see reference section). Solar data can be calculated using the formulae, instructions, and examples provided in the explanatory guide.

This publication can be used in conjunction with other CMHC publications mentioned in the Reference Section.

ACKNOWLEDGEMENTS

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Richard L. Berry
Building and Construction Research Unit
Environment Canada
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Energy, Mines and Resources
Ottawa

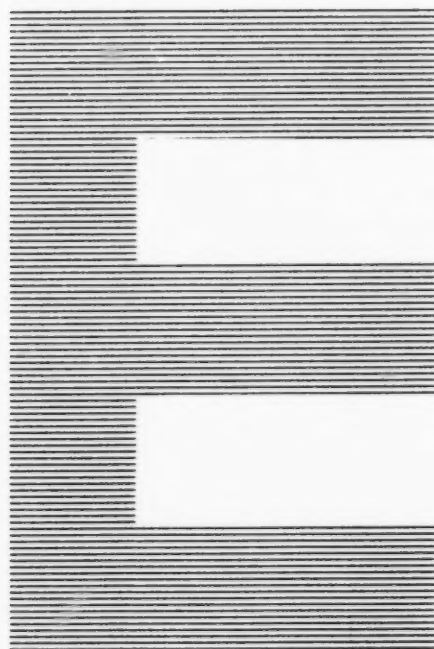
Don Gullett
Atmospheric Environment Service
Environment Canada
Toronto

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Comments and suggestions are invited to further develop the material presented and should be addressed to:

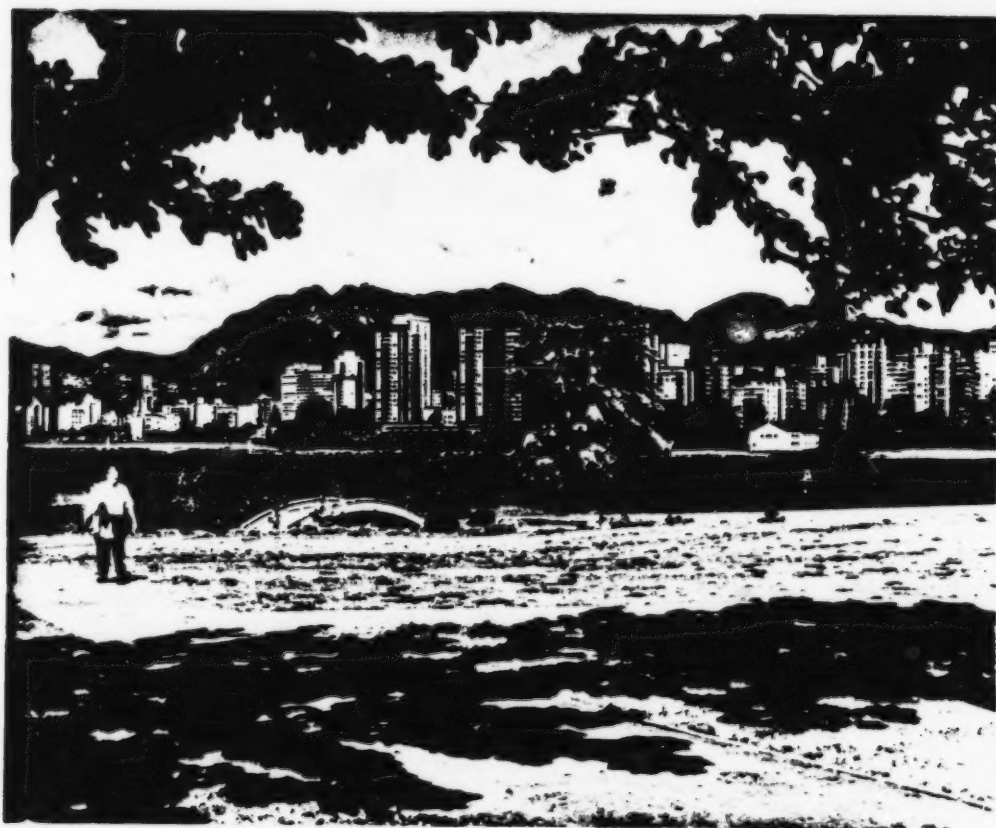
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Section A: ECOCHARTS



VANCOUVER, BRITISH COLUMBIA

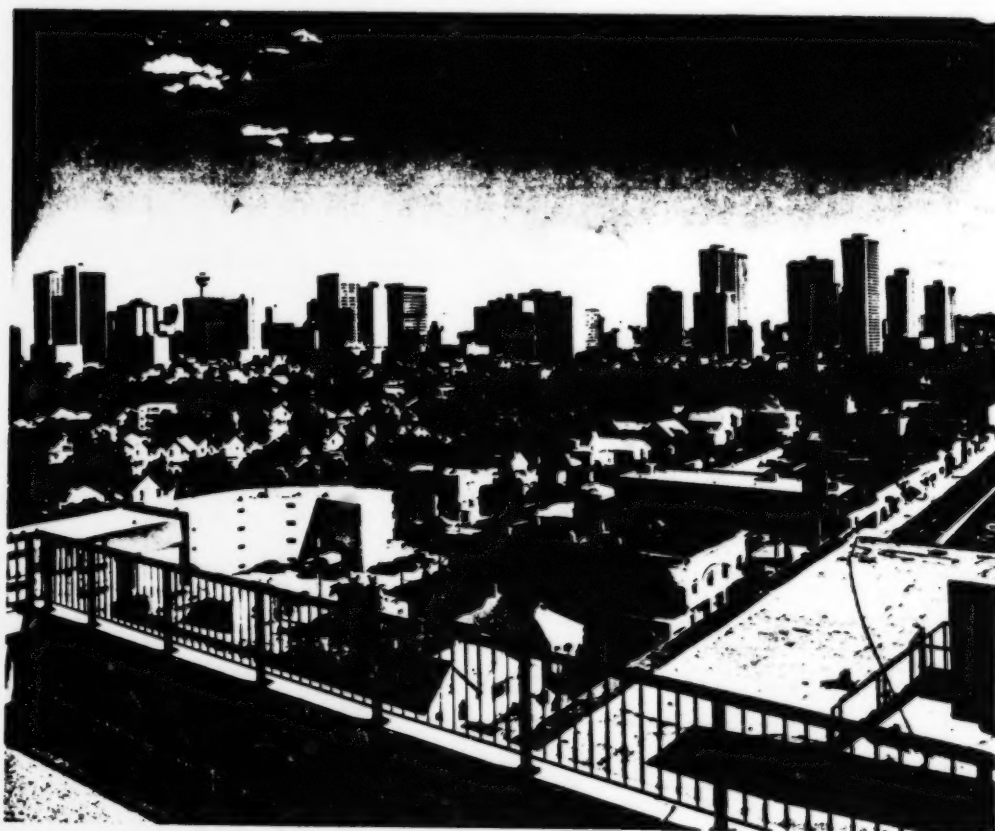
Latitude - $49^{\circ} 15' N$ Longitude - $123^{\circ} 15' W$ Time Zone - 8



VANCOUVER, BRITISH COLUMBIA Latitude - 49° 15' N Longitude - 123° 15' W Time Zone - 8														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		2.94	5.53	10.03	15.09	20.15	21.78	22.95	18.62	13.22	7.38	3.59	2.28	
SELECTED ANGLES FOR MAXIMUM RADIATION	Alt°	180	180	180	135	225	225	225	180	180	180	180	180	180
	Tilt°	60	60	60	30	30	30	30	30	30	60	60	60	30
POSITION OF THE	9 am	132.44	126.98	122.20	116.48	110.32	106.13	107.79	115.32	125.31	133.54	137.77	136.93	
	Alt°	7.37	15.08	25.03	35.76	42.57	44.17	41.23	35.23	27.23	18.46	10.22	5.80	
SUN	12 pm	173.86	172.43	173.31	175.28	175.39	172.27	170.64	173.51	177.99	180.67	180.27	177.32	
	Alt°	20.70	30.01	40.91	52.63	60.93	64.03	60.91	52.63	41.33	29.95	20.77	17.27	
	3 pm	217.28	220.98	228.11	237.71	244.95	246.58	242.46	236.54	231.72	227.48	222.66	218.50	
	Alt°	12.79	21.52	30.37	39.51	45.49	48.70	47.02	39.74	28.73	17.82	9.94	8.18	
SHADOWS (m)	9 am	7.73	3.71	2.14	1.39	1.09	1.03	1.14	1.42	1.94	3.00	5.55	9.84	
	12 pm	2.65	1.73	1.15	0.76	0.56	0.49	0.56	0.76	1.14	1.74	2.64	3.22	
	3 pm	4.41	2.54	1.71	1.21	0.98	0.88	0.93	1.20	1.82	3.11	5.71	6.96	
SUNRISE (hrs)	am	7:57	7:10	6:12	5:08	5:21	5:07	5:31	6:12	6:58	7:43	7:33	8:05	
SUNSET	pm	4:51	5:42	6:27	7:14	8:57	9:22	9:07	8:18	7:13	6:11	4:24	4:16	
MEAN RAINFALL (mm)		130.7	107.1	95.1	59.3	51.6	45.2	32.0	41.1	67.1	114.0	147.0	165.2	1055.4
MEAN SNOWFALL (cm)		25.7	7.5	6.6	0.3							2.8	17.5	60.4
TOTAL PRECIPITATION (mm)		153.8	114.7	101.0	59.6	51.6	45.2	32.0	41.1	67.1	114.0	150.1	182.4	1112.6
RELATIVE HUMIDITY (%)		87	85	82	75	74	76	74	78	80	87	88	89	81
AIR TEMPERATURE (° C)		2.5	4.6	5.8	8.8	12.2	15.1	17.3	17.1	14.2	10.0	5.9	3.9	9.8
DEGREE DAYS		479.7	379.0	378.9	277.2	180.0	91.5	39.4	41.5	114.7	248.0	362.8	438.0	3030.7
PREVAILING WIND DIRECTION		E	E	E	E	E	E	E	E	E	E	E	E	E
AVERAGE SPEED (Km/h)		12.4	12.1	13.2	12.6	11.1	10.9	10.9	10.3	10.6	12.1	13.2	13.7	11.9

CALGARY, ALBERTA

Latitude - 51° 02' N Longitude - 114° 05' W Time Zone - 7



CALGARY, ALBERTA Latitude - 51° 02' N Longitude - 114° 05' W Time Zone - 7														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJ/m ²)		4.69	8.19	13.08	16.97	20.40	21.98	23.28	19.99	14.59	9.47	5.45	3.71	
SELECTED ANGLES FOR MAXIMUM RADIATION	AL*	180	180	180	180	135	135	135	180	180	180	180	180	180
	TIR*	90	60	60	30	30	30	30	30	60	60	60	90	30
POSITION OF THE SUN	9 am	127.87	122.36	117.60	112.07	106.29	102.38	103.87	110.94	120.56	128.72	133.08	132.36	
		3.35	10.97	20.88	31.61	38.46	40.11	37.15	31.10	23.14	14.49	6.34	1.89	
	12 pm	168.18	166.11	166.04	166.52	165.11	161.51	160.73	164.84	170.50	174.16	174.48	171.81	
		18.35	27.55	38.47	50.26	58.53	61.44	58.26	50.18	39.19	28.01	18.83	15.14	
SHADOWS (m)	3 pm	211.85	214.86	221.26	230.15	236.88	238.16	234.10	228.90	225.08	221.69	217.44	213.41	
		13.43	22.40	31.72	41.12	47.88	51.18	49.27	41.65	30.36	19.19	10.99	8.94	
	9 am	17.08	5.16	2.62	1.62	1.26	1.19	1.32	1.66	2.34	3.87	9.00	30.30	
SUNRISE (hrs)	12 pm	3.01	1.92	1.26	0.83	0.61	0.54	0.62	0.83	1.23	1.88	2.93	3.70	
	3 pm	4.19	2.43	1.62	1.15	0.90	0.80	0.86	1.12	1.71	2.87	5.15	6.36	
		8.27	7.36	6.36	5.28	5.37	5.21	5.46	6.31	7.18	8.10	8.03	8.37	
SUNSET		5:08	6:03	6:51	7:41	9:28	9:54	9:38	8:45	7:37	6:31	4:41	4:31	
MEAN RAINFALL (mm)		0.2	0.3	0.2	10.2	41.1	87.6	65.4	55.4	33.2	6.0	0.3	0.1	300.0
MEAN SNOWFALL (cm)		20.8	19.1	19.9	25.9	8.4	1.9			5.9	13.5	16.3	20.8	152.5
TOTAL PRECIPITATION (mm)		16.2	15.5	16.1	32.6	48.7	89.4	65.4	55.4	38.2	17.6	12.7	16.0	423.8
RELATIVE HUMIDITY (%)		71	72	68	58	53	58	57	58	58	54	69	69	62
AIR TEMPERATURE (° C)		-11.8	-7.3	-4.0	3.3	9.4	13.5	16.4	15.2	10.6	5.5	-2.7	-7.8	3.4
DEGREE DAYS	HEATING	922.9	713.6	681.6	441.5	265.8	141.7	68.8	98.5	223.8	386.6	620.3	799.9	5365.0
	COOLING													0.0
PREVAILING WIND DIRECTION		W	S	S	NNW	NNW	NNW	NNW	NNW	NNW	NNW	W	NNW	NNW
AVERAGE SPEED (km/h)		31.2	12.7	13.7	23.7	24.6	21.2	18.5	18.7	23.0	22.2	29.4	22.4	16.6

EDMONTON, ALBERTA

Latitude - 53° 34' N Longitude - 113° 31' W Time Zone - 7



EDMONTON, ALBERTA Latitude - 53° 34' N Longitude - 113° 31' W Time Zone - 7														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJ/m ²)		3.74	7.06	12.61	17.49	20.94	22.54	23.20	18.08	13.07	8.06	4.20	2.78	
SELECTED ANGLES FOR														
MAXIMUM RADIATION		180	180	180	180	180	135	135	180	180	180	180	180	180
		90	60	60	30	30	30	30	30	60	60	60	90	60
POSITION OF THE SUN	9 am	128.42	123.23	118.94	114.02	108.72	104.96	106.23	112.86	121.99	129.71	133.73	132.85	
	12°	2.06	9.89	19.99	30.93	38.03	39.85	36.83	30.48	22.12	13.15	4.85	0.43	
	12 pm	168.88	167.02	167.19	168.01	167.03	163.85	162.91	166.40	171.53	174.90	175.11	172.43	
	12°	15.94	25.17	36.09	47.87	56.16	59.13	55.96	47.81	36.74	25.52	16.34	12.68	
	3 pm	212.07	214.86	220.88	229.16	235.28	236.26	232.49	227.92	224.66	221.67	217.67	213.71	
	12°	11.10	20.12	29.59	39.21	46.18	49.52	47.48	39.71	28.32	17.07	8.77	6.63	
	9 am	27.80	5.74	2.75	1.67	1.28	1.20	1.34	1.70	2.46	4.28	11.79	133.24	
	12 pm	3.50	2.13	1.37	0.90	0.67	0.60	0.68	0.97	1.34	2.09	3.41	4.44	
SHADOWS (m)	3 pm	5.10	2.73	1.76	1.23	0.96	0.85	0.92	1.20	1.86	3.26	6.48	8.60	
	am	8:35	7:39	6:33	5:19	5:23	5:04	5:32	6:24	7:18	7:59	7:13	8:48	
	pm	4:55	5:56	6:49	7:45	9:37	10:07	9:48	8:49	7:35	6:24	4:28	4:15	
MEAN RAINFALL (mm)		1.4	0.5	1.6	8.8	39.4	77.3	88.7	77.9	37.0	9.1	2.5	1.4	345.6
MEAN SNOWFALL (cm)		27.2	21.3	18.7	13.2	3.1				2.2	7.5	15.4	27.1	135.7
TOTAL PRECIPITATION (mm)		24.6	18.8	18.5	21.7	42.5	77.3	88.7	77.9	39.1	16.6	15.7	24.7	466.1
RELATIVE HUMIDITY (%)		76	77	73	58	52	58	63	65	66	61	74	77	67
AIR TEMPERATURE (° C)		-15.0	-9.6	-5.0	4.2	11.3	15.1	17.4	16.2	11.0	5.8	-3.7	-10.4	3.1
DEGREE DAYS		1021.5	779.7	713.7	413.4	209.1	98.7	48.7	78.0	210.4	379.9	650.6	880.0	5483.7
HEATING								0.1						0.1
COOLING														
PREVAILING WIND DIRECTION		S	S	S	S	S	WNW	WNW	S	S	S	S	S	S
AVERAGE SPEED (Km/h)		12.4	13.4	12.7	14.6	15.0	20.1	17.4	11.4	13.7	13.4	13.7	12.7	13.0

SASKATOON, SASKATCHEWAN

Latitude - 52° 07' N Longitude - 106° 39' W Time Zone - 6



SASKATOON, SASKATCHEWAN Latitude - 52° 07' N Longitude - 106° 39' W Time Zone - 6														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		4.47	8.37	13.79	17.39	21.50	22.73	23.10	19.99	13.59	8.45	4.59	3.41	
SELECTED ANGLES FOR MAXIMUM RADIATION		Alt°	180	180	180	180	225	180	180	180	180	180	180	
		Tilt°	90	60	60	30	30	30	30	60	60	60	90	
POSITION OF THE SUN	9 am	121.91	116.23	111.35	105.86	100.34	96.28	98.05	104.77	114.16	122.38	126.99	126.44	
		Alt°	-1.13	6.33	16.14	26.80	33.63	35.30	32.34	26.30	18.48	10.05	2.05	-2.42
	12 pm	160.93	158.13	156.98	155.87	152.97	148.97	148.99	154.29	161.19	165.95	167.10	164.78	
		Alt°	16.05	25.06	35.93	47.71	55.83	58.49	55.29	47.54	37.01	26.15	17.02	13.13
SHADOWS (m)	3 pm	204.75	206.96	212.49	220.48	226.55	227.35	223.39	219.13	216.54	214.15	210.57	206.70	
		Alt°	14.70	23.87	33.67	43.69	50.90	54.27	52.10	44.15	32.63	21.24	12.73	10.35
	9 am		9.01	3.46	1.98	1.50	1.41	1.58	2.02	2.99	5.64	27.94		
SUNRISE (hrs)	12 pm	3.48	2.14	1.38	0.91	0.68	0.61	0.69	0.92	1.33	2.04	3.27	4.29	
	3 pm	3.81	2.26	1.50	1.05	0.81	0.72	0.78	1.03	1.56	2.57	4.43	5.48	
	am	9:01	8:09	7:07	5:57	5:04	4:46	5:02	6:00	6:51	7:42	8:37	9:13	
SUNSET	pm	5:34	6:31	7:21	8:14	10:03	10:31	10:13	9:18	8:07	6:59	5:07	4:56	
MEAN RAINFALL (mm)		0.2	0.3	1.3	11.8	37.8	59.0	54.2	38.1	30.6	8.0	2.9	0.8	245.0
MEAN SNOWFALL (cm)		19.9	18.4	18.5	9.5	2.0				1.2	9.2	13.0	21.4	113.1
TOTAL PRECIPITATION (mm)		17.8	16.4	18.4	21.2	39.9	59.0	54.2	38.1	31.8	17.3	14.7	20.0	348.8
RELATIVE HUMIDITY (%)		76	79	81	62	51	56	59	58	61	63	78	82	67
AIR TEMPERATURE (° C)		-19.3	-14.6	-8.6	3.3	11.1	15.7	18.5	17.2	11.2	4.9	-5.7	-14.1	1.6
DEGREE DAYS		1155.3	920.5	825.1	441.2	217.7	88.0	32.8	60.4	208.2	407.3	711.3	995.1	6062.9
COOLING						0.1	0.7	2.4	1.0	0.1				4.3
PREVAILING WIND DIRECTION		WNW	SW	SE	SE	SE	WNW	W	WNW	WNW	WNW	WNW	WNW	WNW
AVERAGE SPEED (Km/h)		21.9	15.4	21.2	20.8	20.6	22.8	17.2	20.6	23.7	23.7	23.2	22.0	22.5

REGINA, SASKATCHEWAN

Latitude - 50° 28' N Longitude - 104° 36' W Time Zone - 6



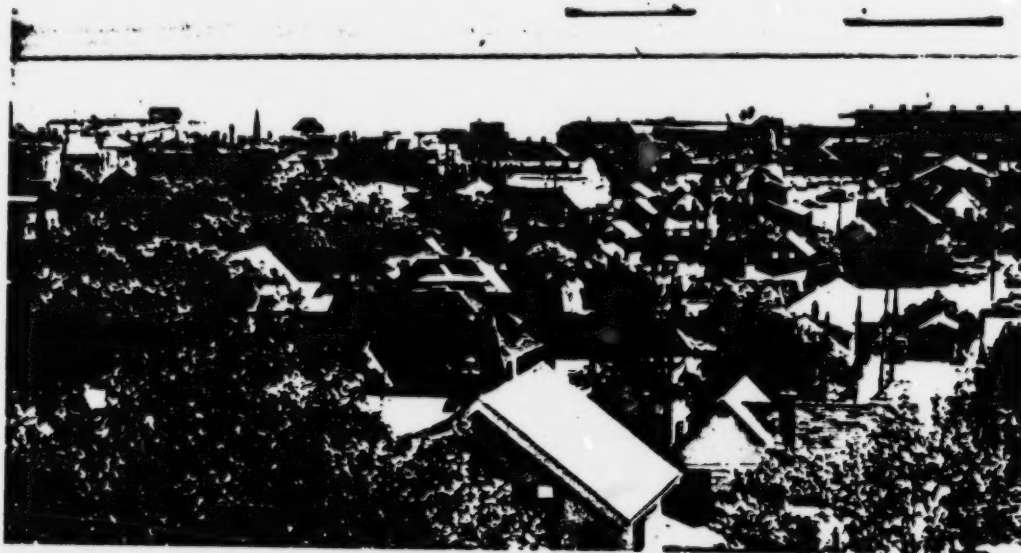
REGINA, SASKATCHEWAN Latitude - 50° 28' N Longitude - 104° 36' W Time Zone - 6														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		5.14	8.91	13.76	17.34	21.43	22.68	23.89	20.52	14.41	9.08	5.20	3.99	
SELECTED ANGLES FOR MAXIMUM RADIATION	Az°	180	180	180	180	135	135	135	180	180	180	180	180	180
	Tilt°	90	60	60	30	30	30	30	180	30	30	60	90	30
POSITION OF THE SUN	9 am	123.51	117.71	112.63	106.82	100.99	97.20	98.71	105.72	115.42	123.85	128.56	128.05	
	12 pm	0.84	8.22	17.95	28.49	35.20	36.77	33.85	27.97	20.33	12.02	4.08	-0.40	
	3 pm	162.75	160.03	159.01	158.08	155.23	151.06	151.02	156.43	163.35	168.00	169.00	166.59	
		18.01	27.06	37.94	49.73	57.87	60.56	57.36	45.97	38.97	28.05	18.90	15.04	
SHADOWS (m)	9 am	206.85	209.43	215.42	224.06	230.72	231.86	227.67	222.74	219.45	216.54	212.63	208.66	
	12 pm	15.63	24.72	34.32	44.05	51.03	54.37	52.34	44.56	33.14	21.85	13.46	11.22	
	3 pm	68.20	6.92	3.09	1.84	1.42	1.34	1.49	1.88	2.70	4.70	14.02		
		3.08	1.92	1.28	0.85	0.63	0.56	0.64	0.85	1.24	1.88	2.92	3.72	
SUNRISE (hrs)	am	8:47	7:57	6:58	5:51	6:02	5:46	6:11	6:56	7:43	8:31	8:23	8:56	
	pm	5:32	6:26	7:12	8:02	9:47	10:13	9:58	9:06	7:59	6:54	5:05	4:56	
MEAN RAINFALL (mm)		0.3	0.8	2.1	14.3	43.5	79.6	53.3	44.8	35.0	11.4	1.4	0.7	287.2
MEAN SNOWFALL (cm)		20.0	18.3	18.3	10.9	3.2				1.8	8.2	14.2	20.8	115.7
TOTAL PRECIPITATION (mm)		16.6	16.1	17.8	23.7	46.4	79.6	53.3	44.8	36.7	18.8	13.5	16.7	384.0
RELATIVE HUMIDITY (%)		76	79	81	62	51	56	59	58	61	63	78	82	67
AIR TEMPERATURE (° C)		-17.9	-13.6	-7.8	3.3	11.1	15.9	18.9	17.8	11.7	5.2	-5.1	-12.8	2.2
DEGREE DAYS		1113.9	894.2	800.1	440.1	221.0	84.0	28.9	50.7	196.9	397.9	693.0	955.9	5876.6
HEATING						0.3	0.4	3.0	2.2	0.1				6.0
COOLING														
PREVAILING WIND DIRECTION		SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE
AVERAGE SPEED (Kmh)		25.4	26.1	26.2	26.1	25.6	23.2	20.1	21.2	22.8	22.4	23.3	25.9	23.9

WINNIPEG, MANITOBA

Latitude - 49° 54' N Longitude - 97° 14' W Time Zone - 6



WINNIPEG, MANITOBA Latitude - 49° 54' N Longitude - 97° 14' W Time Zone - 6														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		5.25	9.05	14.06	17.74	20.90	22.74	22.99	19.00	13.32	8.15	4.64	3.82	
SELECTED ANGLES FOR MAXIMUM RADIATION	AL°	180	180	180	180	135	135	135	135	180	180	180	180	180
	TIR°	90	60	60	30	30	30	30	30	30	30	60	90	30
POSITION OF THE SUN	9 am	129.29	123.73	118.85	113.13	107.11	103.08	104.66	111.96	121.82	130.10	134.50	133.79	
		4.97	12.57	22.44	33.12	39.91	41.51	38.58	32.62	24.74	16.13	7.98	3.53	
	12 pm	169.93	168.02	168.20	169.07	168.02	164.44	163.44	167.33	172.76	176.17	176.29	173.53	
		19.68	28.90	39.82	51.61	59.90	62.87	59.71	51.88	40.50	29.26	20.06	16.41	
	3 pm	213.66	216.95	223.69	232.97	240.04	241.52	237.38	231.78	227.47	223.69	219.19	215.10	
		13.74	22.61	31.75	40.89	47.47	50.73	48.94	41.48	30.31	19.24	11.15	9.21	
SHADOWS (m)	9 am	11.50	4.48	2.42	1.53	1.20	1.13	1.25	1.56	2.17	3.46	7.13	16.21	
	12 pm	2.80	1.81	1.20	0.79	0.58	0.51	0.58	0.79	1.17	1.78	2.74	3.40	
	3 pm	4.09	2.40	1.62	1.15	0.92	0.82	0.87	1.13	1.71	2.87	5.07	6.17	
SUNRISE (hrs)	am	8:15	7:27	6:28	5:23	5:35	5:20	5:44	6:28	7:14	8:00	7:51	8:24	
SUNSET (pm)	pm	5:05	5:57	6:43	7:31	9:15	9:41	9:26	8:35	7:29	6:26	4:38	4:29	
MEAN RAINFALL (mm)		0.2	0.7	3.3	27.1	63.2	80.1	75.9	75.2	53.0	25.9	5.5	0.9	411.0
MEAN SNOWFALL (cm)		23.7	18.9	21.1	11.3	2.5				0.2	5.2	21.9	20.7	125.5
TOTAL PRECIPITATION (mm)		21.3	17.5	22.7	38.5	65.7	80.1	75.9	75.2	53.3	30.9	25.2	19.2	525.5
RELATIVE HUMIDITY (%)		78	79	80	68	56	58	64	63	66	69	78	82	70
AIR TEMPERATURE (° C)		-19.3	-15.6	-8.2	3.4	11.3	16.8	19.6	18.3	12.4	6.1	-4.5	-14.0	2.2
DEGREE DAYS	HEATING	1154.7	948.6	811.3	439.4	219.3	69.9	21.1	43.3	178.1	369.6	676.0	991.8	5923.1
	COOLING					0.5	1.5	4.8	2.9	0.1				9.8
PREVAILING WIND DIRECTION		S	S	S	S	S	S	S	S	S	S	S	S	S
AVERAGE SPEED (Km/h)		24.1	24.1	16.9	23.5	23.8	20.8	18.5	19.1	22.0	22.5	23.5	23.0	22.4

THUNDER BAY, ONTARIO**Latitude - 48° 25' N Longitude - 89° 15' W Time Zone - 5**

THUNDER BAY, ONTARIO Latitude - 48° 25' N Longitude - 89° 15' W Time Zone - 5														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		5.41	9.53	13.76	17.98	20.42	20.60	21.95	18.51	12.69	7.59	4.84	3.88	
SELECTED ANGLES FOR MAXIMUM RADIATION		180	180	180	180	180	225	225	180	180	180	180	180	180
		90	60	60	30	30	30	30	30	30	60	60	90	30
POSITION OF THE SUN	9 am	123.74	117.72	112.30	106.05	99.86	95.95	97.62	104.94	115.01	123.75	128.70	128.32	
		2.16	9.37	18.93	29.28	35.79	37.23	34.37	28.75	21.42	13.36	5.54	1.04	
	12 pm	162.89	160.04	158.86	157.66	154.40	149.83	149.97	155.93	163.30	168.15	169.20	166.78	
		20.03	29.05	39.92	51.70	59.82	62.45	59.26	51.55	41.01	30.11	20.96	17.09	
SHADOWS (m)	3 pm	207.46	210.27	216.66	225.91	233.19	234.66	230.18	224.60	220.72	217.40	213.23	209.19	
		17.34	26.37	35.83	45.33	52.10	55.41	53.53	45.90	34.58	23.36	15.07	12.90	
	9 am	26.51	6.06	2.92	1.78	1.39	1.32	1.46	1.82	2.55	4.21	10.31	55.09	
		2.74	1.80	1.20	0.79	0.58	0.52	0.59	0.79	1.15	1.72	2.61	3.25	
SUNRISE (hrs)	3 pm	3.20	2.02	1.39	0.99	0.78	0.69	0.74	0.97	1.45	2.32	3.71	4.37	
		8.38	7.53	6.58	5.55	5.09	4.55	5.18	5.58	6.41	7.25	8.13	8.45	
SUNSET		5.38	6.28	7.11	7.57	9.37	10.02	9.48	9.01	7.57	6.57	5.12	5.05	
MEAN RAINFALL (mm)		1.9	1.9	13.7	35.4	69.2	76.6	75.4	83.1	89.1	51.6	25.3	4.1	527.3
MEAN SNOWFALL (cm)		48.4	30.7	34.2	16.2	4.2					3.3	29.8	46.2	213.0
TOTAL PRECIPITATION (mm)		40.9	28.3	45.0	50.7	73.3	76.6	75.4	83.1	89.1	54.8	52.9	41.7	711.8
RELATIVE HUMIDITY (%)		80	75	73	67	63	70	71	75	80	77	81	79	74
AIR TEMPERATURE (° C)		-15.4	-13.0	-6.3	2.5	8.8	14.0	17.6	16.4	11.1	5.7	-2.6	-11.1	2.3
DEGREE DAYS HEATING COOLING		1034.9	876.5	752.5	464.9	285.6	126.1	44.6	72.8	210.0	381.2	617.7	901.1	5767.9
PREVAILING WIND DIRECTION		W	W	E	E	E	E	W	W	W	W	W	W	W
AVERAGE SPEED (Km/h)		17.2	16.3	16.4	17.5	16.9	14.8	13.7	12.7	13.8	15.8	16.3	17.2	15.6

WINDSOR, ONTARIO**Latitude - 42° 22' N****Longitude - 83° 00' W****Time Zone - 5**

WINDSOR ONTARIO, Latitude - 42° 22' N Longitude - 83° 00' W Time Zone - 5														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		6.15	9.70	12.62	17.82	20.29	21.94	22.47	17.97	15.07	10.47	5.97	4.66	
SELECTED ANGLES FOR MAXIMUM RADIATION	Az°	180	180	180	180	0	0	0	180	180	180	180	180	180
	Tilt°	60	60	30	30	0	0	0	30	30	60	60	60	30
POSITION OF THE SUN	9 am	127.97	121.48	115.22	107.65	100.19	95.78	98.01	106.54	117.87	127.49	132.88	132.63	
	12 pm	9.26	16.17	25.38	35.24	41.17	42.23	39.55	34.62	28.05	20.45	12.81	8.31	
	3 pm	168.55	166.06	165.53	165.37	162.61	157.06	156.82	163.28	170.62	174.89	175.26	172.45	
		26.97	36.11	47.02	58.82	67.05	69.82	66.63	58.75	47.90	36.74	27.54	23.83	
SHADOWS (m)	9 am	214.26	218.41	226.55	237.97	247.08	249.66	244.67	236.83	230.38	225.14	219.76	215.41	
	12 pm	20.28	28.89	37.44	45.60	51.30	54.34	53.08	46.33	35.68	25.01	17.32	15.67	
	3 pm	6.13	3.45	2.11	1.42	1.14	1.10	1.21	1.45	1.88	2.68	4.40	6.85	
		1.97	1.37	0.93	0.61	0.42	0.37	0.43	0.61	0.90	1.34	1.92	2.26	
SUNRISE (hrs)	am	7:55	6:19	6:33	5:42	6:04	5:55	6:12	6:45	7:16	7:51	7:30	7:57	
SUNSET (pm)	pm	5:31	6:11	6:44	7:19	8:52	9:12	9:02	8:23	7:31	6:40	5:05	5:02	
MEAN RAINFALL (mm)		28.1	28.5	51.9	78.3	70.2	89.3	83.4	84.1	67.0	56.9	53.6	46.2	737.5
MEAN SNOWFALL (cm)		30.2	22.8	20.0	4.2						0.1	11.5	28.6	117.4
TOTAL PRECIPITATION (mm)		55.0	50.3	71.7	83.0	70.2	89.3	83.4	84.1	67.0	57.1	65.2	72.5	848.8
RELATIVE HUMIDITY (%)		82	81	78	71	65	68	69	76	76	75	78	82	75
AIR TEMPERATURE (° C)		-4.9	-3.8	1.2	8.1	14.2	19.7	22.2	21.3	17.4	11.1	4.4	-1.9	9.1
DEGREE DAYS	HEATING	709.3	616.0	520.6	299.1	135.8	27.6	2.6	6.8	61.0	218.1	409.6	615.9	3622.4
	COOLING					0.3	7.9	15.6	8.9	3.4	5.2			36.1
PREVAILING WIND DIRECTION		SW	WNW	WNW	SSW	SSW	SSW	SW	SW	SSW	SSW	SW	SW	SW
AVERAGE SPEED (Km/h)		20.9	24.5	24.3	21.9	20.1	16.7	14.8	14.2	16.9	18.2	20.6	20.4	18.7

LONDON, ONTARIO

Latitude - 42° 59' N

Longitude - 81° 14' W

Time Zone - 5



LONDON, ONTARIO Latitude - 42° 59' N Longitude - 81° 14' W Time Zone - 5														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJm ²)	SELECTED ANGLES FOR	5.77	9.34	12.64	17.43	19.57	21.53	21.76	19.37	14.23	9.71	5.17	4.33	
	MAXIMUM RADIATION	180	180	180	180	135	135	135	180	180	180	180	180	180
POSITION OF THE SUN	9 am	60	60	30	30	30	30	30	30	30	60	60	60	30
		129.39	123.04	116.96	109.57	102.15	97.68	96.89	108.43	119.70	129.17	134.39	134.03	
	12 pm	9.89	16.94	26.28	36.27	42.32	43.44	40.73	35.67	28.89	21.09	13.33	8.83	
	3 pm	170.45	168.27	168.23	168.87	167.13	162.14	161.33	166.79	173.33	177.08	177.14	174.24	
SHADOWS (m)	9 am	26.60	35.80	46.71	58.51	66.79	69.70	66.52	58.49	47.47	36.22	27.02	23.36	
	12 pm	215.71	219.94	228.06	239.31	248.19	250.67	245.85	238.21	231.82	226.55	221.13	216.80	
	3 pm	19.03	27.59	36.06	44.17	49.87	52.91	51.64	44.90	34.28	23.65	16.00	14.40	
		5.74	3.28	2.03	1.36	1.10	1.06	1.16	1.39	1.81	2.59	4.22	6.44	
SUNRISE (hrs)	12 pm	2.00	1.39	0.94	0.61	0.43	0.37	0.43	0.61	0.92	1.37	1.96	2.32	
	3 pm	2.90	1.91	1.37	1.03	0.84	0.76	0.79	1.00	1.47	2.28	3.49	3.89	
	am	7.49	7:13	6:25	5:32	5:55	5:45	6:13	6:36	7:11	7:44	7:25	7:53	
	pm	5:23	6:03	6:38	7:14	9:47	10:05	9:58	8:18	7:24	6:33	4:55	4:53	
MEAN RAINFALL (mm)		27.9	26.7	49.7	72.6	66.5	73.6	72.4	80.3	78.6	71.6	62.4	43.5	725.8
MEAN SNOWFALL (cm)		55.0	38.9	27.9	9.1	0.3					1.9	24.4	51.3	208.8
TOTAL PRECIPITATION (mm)		75.2	60.5	75.1	81.2	66.9	73.6	72.4	80.3	78.6	73.4	84.7	87.5	909.4
RELATIVE HUMIDITY (%)		84	82	81	73	68	69	69	74	78	78	84	86	77
AIR TEMPERATURE (° C)		-6.6	-6.1	-0.9	6.4	12.4	17.9	20.3	19.5	15.4	9.4	3.1	-3.5	7.3
DEGREE DAYS		763.2	681.5	585.9	349.7	183.2	51.3	13.2	22.1	101.2	267.4	448.0	665.8	4132.5
COOLING							2.5	5.1	3.4	1.0				12.0
PREVAILING WIND DIRECTION		W	W	E	E	E	S	SSW	W	E	W	WSW	WSW	W
AVERAGE SPEED (Km/h)		22.4	21.7	23.8	23.5	18.0	13.5	15.1	13.5	13.7	16.6	21.1	21.1	17.9

TORONTO, ONTARIO**Latitude - 43° 40' N****Longitude - 79° 24' W****Time Zone - 5**

TORONTO, ONTARIO Latitude - 43° 40' N Longitude - 79° 24' W Time Zone - 5													AN.
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		5.19	8.20	12.05	16.07	19.83	21.97	21.94	18.68	14.04	9.24	4.82	3.90
SELECTED ANGLES FOR MAXIMUM RADIATION	Az°	180	180	180	180	180	135	135	180	180	180	180	180
	Tilt°	60	60	60	30	30	30	30	30	30	60	60	30
POSITION OF THE SUN	9 am	130.89	124.71	118.84	111.66	104.31	99.79	101.96	110.48	121.67	130.97	135.99	135.52
		10.47	17.67	27.14	37.28	43.46	44.66	41.91	36.70	29.69	21.67	13.78	9.29
	12 pm	172.41	170.56	171.00	172.44	171.70	167.33	165.95	170.38	176.09	179.32	179.08	176.09
		26.12	35.37	46.28	58.06	66.37	69.39	66.24	58.08	46.91	35.57	26.38	22.80
SHADOWS (m)	3 pm	217.19	221.49	229.58	240.64	249.27	251.65	246.99	239.57	233.25	227.97	222.54	218.21
		17.68	26.20	34.61	42.67	48.38	51.43	50.14	43.41	32.81	22.21	14.60	13.05
		9 am	5.41	3.14	1.95	1.31	1.06	1.11	1.34	1.75	2.52	4.08	6.11
SUNRISE (hrs)	12 pm	2.04	1.41	0.96	0.62	0.44	0.38	0.44	0.62	0.94	1.40	2.02	2.38
	3 pm	3.14	2.03	1.45	1.08	0.89	0.80	0.83	1.06	1.55	2.45	3.84	4.31
	pm	7:45	7:08	6:19	5:25	4:47	4:36	4:55	5:29	6:03	6:39	7:19	7:48
MEAN RAINFALL (mm)	pm	5:13	5:55	6:30	7:07	8:42	9:02	8:52	8:12	7:17	6:24	4:47	4:43
	TOTAL PRECIPITATION (mm)	25.9	23.8	43.9	65.4	65.7	63.9	74.0	73.1	66.2	60.4	60.9	40.7
		36.4	28.5	24.7	7.6	0.1					0.6	7.4	33.9
RELATIVE HUMIDITY (%)		60.9	51.8	69.7	72.9	65.8	63.9	74.0	73.1	66.2	61.0	68.4	72.8
AIR TEMPERATURE (° C)		80	79	74	75	62	64	64	70	74	71	80	81
DEGREE DAYS	HEATING	-4.6	-3.9	0.7	7.6	13.6	19.1	22.0	21.2	17.1	11.0	4.9	-1.6
	COOLING	700.8	617.5	535.6	314.2	150.3	30.7	3.3	6.9	66.5	220.1	392.5	607.5
PREVAILING WIND DIRECTION						0.2	2.5	7.1	5.1	2.1			
AVERAGE SPEED (Km/h)		W	W	E	E	E	E	E	E	E	E	W	E
		21.1	21.4	21.4	19.5	15.8	14.5	12.7	13.4	13.7	15.1	21.1	20.9

OTTAWA, ONTARIO**Latitude - 45° 23' N****Longitude - 75° 42' W****Time Zone - 5**

OTTAWA, ONTARIO Latitude - 45° 23' N Longitude - 75° 42' W Time Zone - 5																		
DATA VARIABLES				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.		
MEAN DAILY SOLAR RADIATION (MJm ⁻²)				5.74	9.44	13.61	16.75	19.88	21.37	21.28	18.11	13.36	8.58	4.72	4.33			
SELECTED ANGLES FOR				180	180	180	180	135	135	135	180	180	180	180	180	180		
MAXIMUM RADIATION				60	60	60	30	30	30	30	30	30	60	60	60	30		
POSITION OF THE SUN				134.07	128.27	122.93	116.33	109.27	104.68	106.72	115.08	125.96	134.80	139.36	138.63			
				11.25	18.77	28.52	38.99	45.50	46.87	44.04	38.47	30.92	22.43	14.29	9.83			
SHADOWS (m)				176.33	175.11	176.46	179.33	180.36	177.24	174.92	177.36	181.46	183.71	182.92	179.77			
				24.68	34.00	44.87	56.53	64.84	68.04	64.99	56.65	45.25	33.79	24.61	21.18			
SUNRISE (hrs)				220.07	224.43	232.39	243.01	251.09	253.24	248.91	241.97	235.93	230.73	225.30	221.00			
				14.70	23.15	31.48	39.53	45.31	48.40	47.06	40.27	29.66	19.09	11.54	10.05			
SUNSET				9 am	5.03	2.94	1.84	1.24	0.98	0.94	1.03	1.26	1.67	2.42	3.93	5.77		
				12 pm	2.18	1.48	1.00	0.66	0.47	0.40	0.47	0.66	0.99	1.49	2.18	2.58		
				3 pm	3.81	2.34	1.63	1.21	0.99	0.89	0.93	1.18	1.76	2.89	4.90	5.64		
MEAN RAINFALL (mm)				15.4	12.9	31.7	59.5	66.2	73.4	85.9	88.4	79.3	65.3	55.4	29.5	662.9		
MEAN SNOWFALL (cm)				50.3	50.2	35.7	8.2	1.2					2.7	22.8	56.2	227.3		
TOTAL PRECIPITATION (mm)				61.0	60.3	67.5	69.1	67.9	73.4	85.9	88.4	79.3	68.1	77.7	80.7	879.3		
RELATIVE HUMIDITY (%)				75	71	69	60	58	61	66	68	72	71	75	78	69		
AIR TEMPERATURE (° C)				-10.9	-9.5	-3.0	5.6	12.8	18.0	20.6	19.2	14.3	8.1	1.2	-7.7	5.7		
DEGREE DAYS				896.3	777.2	650.4	374.5	174.4	44.6	10.7	27.1	127.5	306.4	504.2	797.6	4640.9		
PREVAILING WIND DIRECTION								0.3	2.2	6.8	3.3	0.9				13.5		
				WNW	WNW	WNW	WNW	SW	SW	SW	SW	SW	SW	SW	E	E	WNW	WNW
AVERAGE SPEED (Km/h)				20.6	21.7	20.9	20.1	15.9	14.6	13.0	13.5	14.5	15.4	17.7	20.1	18.8		

MONTREAL, QUEBEC

Latitude - $45^{\circ} 31' N$ Longitude - $73^{\circ} 37' W$ Time Zone - 5



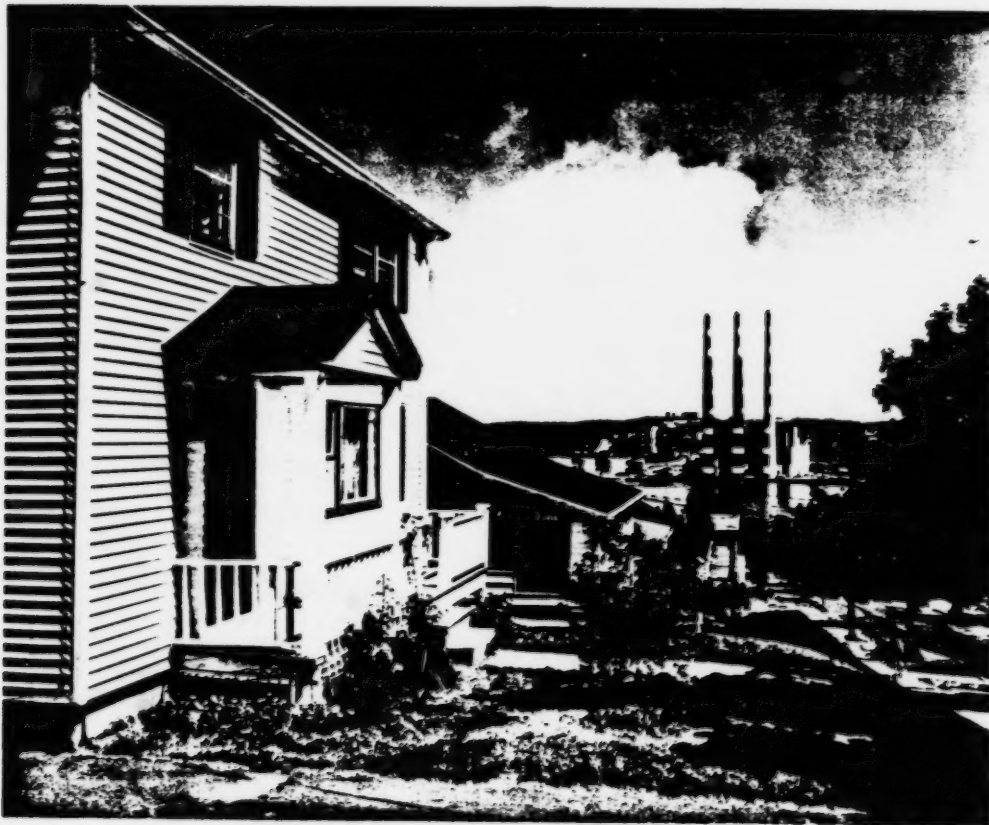
MONTREAL, QUEBEC Latitude - 45° 31' N Longitude - 73° 37' W Time Zone - 5														JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.	
DATA VARIABLES		MEAN DAILY SOLAR RADIATION (MJm ⁻²)		SELECTED ANGLES FOR MAXIMUM RADIATION		POSITION OF THE SUN		SHADOWS (m)		SUNRISE (hrs)		SUNSET		MEAN RAINFALL (mm)		MEAN SNOWFALL (cm)		TOTAL PRECIPITATION (mm)		RELATIVE HUMIDITY (%)		AIR TEMPERATURE (° C)		DEGREE DAYS HEATING COOLING		PREVAILING WIND DIRECTION AVERAGE SPEED (Km/h)	
		5.30		180		60		12.51		15.87		19.07		20.25		20.96		17.23		13.45		8.04		4.61		3.92	
		180		180		60		180		180		180		225		135		180		180		180		180		180	
		60		60		60		60		30		30		30		30		30		30		60		60		30	
		135.79		130.12		124.93		118.47		111.41		106.74		108.77		117.19		128.04		136.77		141.16		140.33			
		12.19		19.81		29.66		40.23		46.82		48.24		45.40		39.72		32.01		23.36		15.12		10.68			
		178.49		177.59		179.40		183.01		184.93		182.34		179.54		181.07		184.40		186.15		185.07		181.82			
		24.61		33.96		44.78		56.37		64.63		67.91		64.92		56.54		45.40		33.53		24.38		21.02			
		221.81		226.30		234.33		244.91		252.90		255.03		250.79		243.91		237.79		232.48		226.96		222.65			
		13.64		22.01		30.23		38.16		43.88		46.95		45.64		38.90		28.37		17.86		10.39		8.97			
		4.63		2.78		1.76		1.18		0.94		0.89		0.98		1.20		1.60		2.32		3.70		5.30			
		2.18		1.48		1.01		0.67		0.47		0.41		0.47		0.66		0.99		1.51		2.21		2.60			
		4.12		2.47		1.72		1.27		1.04		0.93		0.98		1.24		1.85		3.10		5.45		6.34			
		7:26		6:46		5:55		5:58		5:16		5:04		5:24		6:01		6:38		7:17		7:00		7:30			
		4:45		5:29		6:08		6:48		8:25		8:47		8:35		7:52		6:54		5:59		4:18		4:14			
		23.7		14.9		36.8		63.5		63.9		82.2		90.0		91.9		88.4		73.8		61.2		32.6		722.9	
		52.7		53.6		35.7		9.7		1.7										1.7		21.2		58.8		235.1	
		72.0		65.2		73.6		74.1		65.6		82.2		90.0		91.9		88.4		75.5		81.0		86.7		946.2	
		75		76		71		63		58		64		67		68		71		70		76		78		70	
		-10.2		-9.0		-2.5		5.7		13.0		18.3		20.9		19.6		14.8		8.7		2.0		-6.9		6.2	
		874.0		762.5		636.5		368.5		165.8		40.6		8.3		23.1		116.1		289.3		481.0		771.8		4537.5	
										0.2		2.2		7.9		3.7		1.0								15.0	
		WSW		WSW		WSW		W		SW		SW		SW		SW		W		W		W		W		WSW	
		23.0		24.0		23.3		19.3		18.5		17.4		15.8		15.8		17.5		17.2		20.3		20.1		20.3	

QUEBEC CITY, QUEBEC**Latitude - 46° 48' N****Longitude - 71° 14' W****Time Zone - 5**

QUEBEC CITY, QUEBEC Latitude - 46° 48' N Longitude - 71° 14' W Time Zone - 5														
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.
MEAN DAILY SOLAR RADIATION (MJ/m ²)		5.58	8.73	12.91	16.36	18.55	19.87	19.61	16.69	11.97	8.07	4.54	4.24	
SELECTED ANGLES FOR MAXIMUM RADIATION	Az°	180	180	180	180	180	0	0	180	180	180	180	180	180
	Tilt°	60	60	60	30	30	0	0	30	30	60	60	60	30
POSITION OF THE SUN	9 am	137.96	132.58	127.81	121.85	115.12	110.45	112.33	120.53	131.05	139.39	143.45	142.45	
	12 pm	12.39	20.21	30.23	41.01	47.83	49.40	46.49	40.55	32.47	23.50	15.12	10.71	
	3 pm	180.95	180.41	182.70	186.97	189.66	187.70	184.59	185.12	187.60	188.82	187.44	184.13	
		23.33	32.70	43.47	54.95	63.15	66.49	63.58	55.17	43.59	32.04	22.92	19.65	
SHADOWS (m)	9 am	223.61	228.09	235.99	246.26	253.91	255.89	251.83	245.28	239.39	234.19	228.71	224.41	
	12 pm	11.58	19.93	28.14	36.13	41.93	45.03	43.66	36.86	26.29	15.77	8.31	6.90	
	3 pm	4.55	2.72	1.72	1.15	0.91	0.86	0.95	1.17	1.57	2.30	3.70	5.29	
		2.32	1.56	1.05	0.70	0.51	0.44	0.50	0.70	1.05	1.60	2.37	2.80	
SUNRISE (hrs)	am	7:15	6:38	5:45	4:46	5:03	4:50	5:12	5:50	6:30	7:10	6:55	7:26	
	pm	4:31	5:18	5:58	6:41	8:20	8:43	8:30	7:45	6:45	5:48	5:05	4:59	
MEAN RAINFALL (mm)		17.2	11.2	26.1	55.1	85.9	109.9	116.6	117.1	119.4	86.4	62.9	28.6	836.4
MEAN SNOWFALL (cm)		77.5	70.2	54.2	16.2	0.9					4.4	33.9	86.1	343.4
TOTAL PRECIPITATION (mm)		89.8	78.1	82.0	72.8	86.9	109.9	116.6	117.1	119.4	90.7	97.1	113.6	1174.0
RELATIVE HUMIDITY (%)		73	71	68	61	54	60	66	73	74	75	79	80	70
AIR TEMPERATURE (° C)		-12.1	-10.8	-4.5	3.3	10.8	16.4	19.1	17.5	12.6	6.6	-0.2	-9.0	4.1
DEGREE DAYS	HEATING	931.9	815.1	698.4	442.5	227.2	72.8	23.3	48.2	169.3	352.0	546.5	838.0	5165.2
	COOLING						0.4	2.7	0.5					3.6
PREVAILING WIND DIRECTION		WSW	WSW	ENE	ENE	ENE	SW	SW	WSW	WSW	WSW	ENE	WSW	WSW
AVERAGE SPEED (Km/h)		24.8	24.9	23.2	20.4	19.5	19.8	17.5	17.7	18.8	19.6	20.8	24.1	21.2

HALIFAX, NOVA SCOTIA

Latitude - 44° 39' N Longitude - 63° 35' W Time Zone - 4



HALIFAX, NOVA SCOTIA Latitude - 44° 39' N Longitude - 63° 35' W Time Zone - 4															
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.	
MEAN DAILY SOLAR RADIATION (MJm ²)		5.11	8.14	12.09	14.54	17.38	20.00	19.11	17.94	13.98	8.96	5.32	3.85		
SELECTED ANGLES FOR		Az°	180	180	180	180	225	225	180	180	180	180	180	180	
MAXIMUM RADIATION		TWR°	60	60	30	30	30	30	30	30	60	60	60	30	
POSITION OF THE SUN		9 am	Az°	131.67	125.65	120.00	113.10	105.94	101.43	103.51	111.88	122.87	131.98	136.82	
		12 pm	Az°	10.25	17.56	27.15	37.43	43.77	45.05	42.27	36.90	29.67	21.47	13.48	9.00
SHADOWS (m)		3 pm	Az°	173.32	171.64	172.31	174.10	173.85	169.91	168.28	172.10	177.32	180.30	179.94	
			Az°	25.21	34.48	45.38	57.13	65.46	68.54	65.42	57.21	45.98	34.61	25.41	21.85
SUNRISE (hrs) SUNSET			Az°	217.71	221.94	229.88	240.68	249.04	251.30	246.78	239.63	233.55	228.41	223.05	
			Az°	16.54	25.06	33.52	41.67	47.47	50.56	49.22	42.41	31.77	21.13	13.49	11.91
			9 am	5.53	3.16	1.95	1.31	1.04	1.00	1.10	1.33	1.76	2.54	4.17	6.31
			12 pm	2.12	1.46	0.99	0.65	0.46	0.39	0.46	0.64	0.97	1.45	2.11	2.49
			3 pm	3.37	2.14	1.51	1.12	0.92	0.82	0.86	1.09	1.61	2.59	4.17	
			sun	7.43	7.05	6.16	5.20	5.40	5.28	5.48	6.23	6.59	7.37	7.18	
			pm	5.07	5.51	6.27	7.06	8.41	9.03	8.52	8.10	7.14	6.20	4.41	
MEAN RAINFALL (mm)			91.0	70.0	83.2	89.3	102.8	89.4	94.2	111.3	93.7	129.9	140.7	128.3	
MEAN SNOWFALL (cm)			63.1	65.5	45.5	24.1	3.4					3.6	11.9	53.9	
TOTAL PRECIPITATION (mm)			152.8	133.5	128.4	114.8	106.4	89.4	94.2	111.3	93.7	133.5	152.5	180.1	
RELATIVE HUMIDITY (%)			83	80	76	75	69	74	80	79	81	82	86	84	
AIR TEMPERATURE (° C)			-6.0	-6.1	-1.6	3.3	9.2	14.8	18.2	18.1	13.8	8.6	3.4	-2.9	
DEGREE DAYS		HEATING	743.1	680.1	609.0	440.7	274.7	106.6	29.3	32.8	131.3	292.7	437.8	646.6	
		COOLING						0.3	0.5	0.2	0.1				
PREVAILING WIND DIRECTION			WNW	WNW	WNW	N	SSW	SSW	SSW	SSW	SSW	SSW	WNW	WNW	
AVERAGE SPEED (K/m/h)			23.2	21.4	22.8	20.8	22.4	21.7	20.4	19.3	20.1	18.7	19.3	23.2	

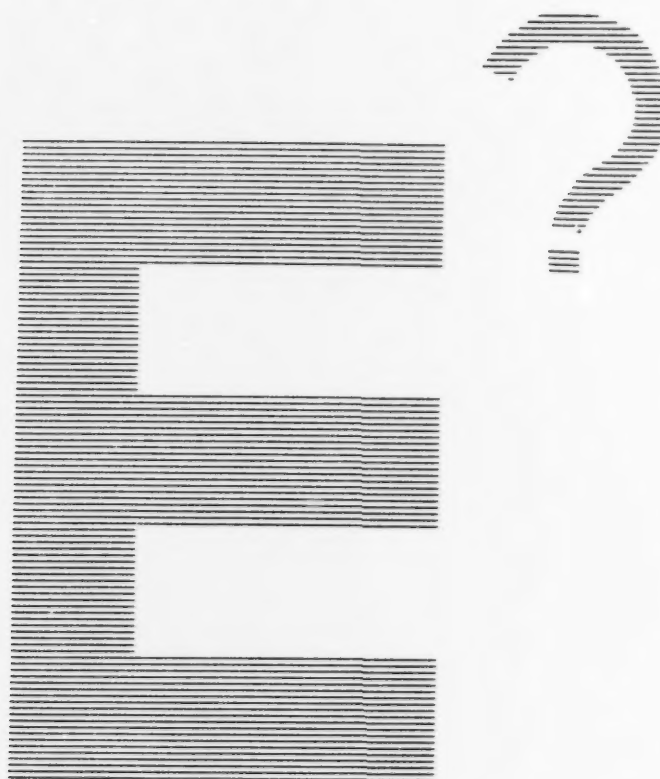
ST. JOHN'S, NEWFOUNDLAND

Latitude - $47^{\circ} 34' N$ Longitude - $52^{\circ} 43' W$ Time Zone - 3.5



ST. JOHN'S, NEWFOUNDLAND Latitude - 47° 34' N Longitude - 52° 43' W Time Zone - 3.5															
DATA VARIABLES		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AN.	
MEAN DAILY SOLAR RADIATION (MJm ⁻²)		4.14	7.08	10.42	13.60	16.54	19.60	19.94	15.72	12.02	6.82	4.11	3.03		
SELECTED ANGLES FOR MAXIMUM RADIATION	As°	180	180	180	180	225	225	225	180	180	180	180	180	180	
	TIR°	60	60	60	30	30	30	30	30	30	60	60	60	30	
POSITION OF THE SUN	9 am	134.77	129.26	124.36	118.36	111.81	107.36	109.15	117.07	127.43	135.85	140.11	139.26		
		As°	9.95	17.64	27.57	45.03	46.59	43.70	37.82	29.90	21.13	12.85	8.41		
	12 pm	176.89	175.79	177.24	180.17	181.33	178.56	176.29	178.31	182.06	184.17	183.37	180.25		
		As°	22.50	31.83	42.68	54.33	62.64	65.87	62.85	54.51	43.08	31.61	22.43	18.99	
SHADOWS (m)	3 pm	220.14	224.24	231.82	241.90	249.50	251.41	247.27	240.88	235.39	230.60	225.41	221.17		
		As°	12.80	21.33	29.86	38.21	44.25	47.41	45.94	38.92	28.18	17.47	9.78	8.18	
	9 am	5.70	3.14	1.92	1.27	1.00	0.95	1.05	1.29	1.74	2.59	4.38	6.76		
		12 pm	2.41	1.61	1.08	0.72	0.52	0.45	0.51	0.71	1.07	1.62	2.42	2.91	
SUNRISE (hrs)	3 pm	4.40	2.56	1.74	1.27	1.03	0.92	0.97	1.24	1.87	3.18	5.80	6.96		
		7.39	6.55	6.01	5.00	5.16	5.03	5.25	6.04	6.46	7.28	7.14	7.46		
	sun	4.45	5.33	6.14	6.58	8.38	9.02	8.49	8.02	7.01	6.02	4.18	4.11		
	pm	77.9	69.7	67.0	78.1	89.4	83.4	75.3	121.6	116.7	140.9	140.6	96.7	1157.3	
MEAN RAINFALL (mm)		81.4	74.6	65.0	34.6	11.1	2.0				4.4	21.2	65.1	359.4	
MEAN SNOWFALL (cm)		155.8	140.1	131.9	115.6	101.8	85.6	75.3	121.6	116.7	145.5	162.5	161.2	1513.6	
TOTAL PRECIPITATION (mm)		85	86	88	83	78	78	78	81	80	83	86	85	83	
RELATIVE HUMIDITY (%)		-3.9	-4.5	-2.3	1.2	5.4	10.9	15.5	15.3	11.6	6.9	3.4	-1.5	4.8	
AIR TEMPERATURE (° C)		678.0	635.4	630.1	504.6	390.6	216.0	93.1	95.3	193.5	343.6	439.1	605.1	4824.4	
DEGREE DAYS														0.0	
HEATING															
COOLING															
PREVAILING WIND DIRECTION		W	W	WSW	WSW	WSW	WSW	WSW	WSW	WSW	WSW	W	W	WSW	
AVERAGE SPEED (Km/h)		30.7	30.1	28.5	27.7	27.0	26.9	25.4	24.1	24.8	24.6	26.2	28.2	26.9	

Section B: ECOCHART EXPLANATORY GUIDE



MEAN DAILY GLOBAL SOLAR RADIATION

Global solar radiation is a primary influence in the design and construction of any building site. The amount received varies according to the time of year, climate, and topography of the site. Global solar radiation is the total incoming direct and diffuse short-wave solar radiation received from the whole dome of the sky on a horizontal surface.

The values provided in the Ecocharts are averaged daily totals of global radiation in megajoules per square metre. To compute the monthly mean, the daily values for that month are summed and averaged.

Unit Conversion

MJm ⁻²	LANGLEYS	BTU ft ²
1.0	= 23.895	= 88.114
0.04185	= 1.0	= 3.688
0.01135	= 0.2712	= 1.0

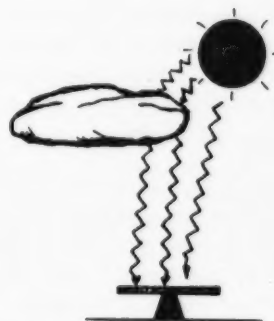


Figure 1 - GLOBAL SOLAR RADIATION

SELECTED ANGLES REPRESENTING MAXIMUM SOLAR RADIATION RECEPTION

The proper orientation of housing is a critical factor in reducing energy consumption for winter heating. A more energy efficient house is south facing, though, south west and southeast orientations are also satisfactory. The monthly azimuth and tilt angles shown in the Ecocharts correspond to the reception of the largest radiation counts. These angles are general values only and are not necessarily the exact optimum.

The Ecochart values were taken from computer printouts entitled "Mean Daily Global Solar Radiation on a Sloped Surface," supplied by Environment Canada. Radiation counts are provided for combinations of six azimuth and four tilt angles. The angles were synthetically derived using various climatic data.

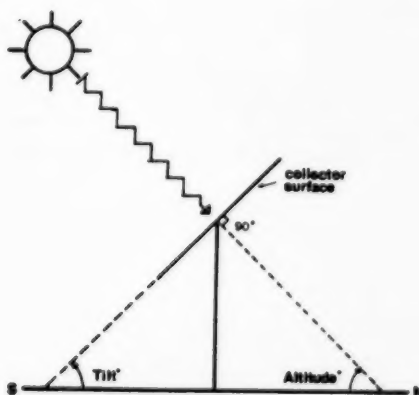


Figure 2 - Angles of a tilted surface

POSITION OF THE SUN

The earth orbits the sun along an ecliptic path once a year. The earth also rotates daily about its own axis. This rotation causes the sun's apparent motion from east to west. Time measurement based on this apparent motion is called true solar or apparent solar time. Unfortunately, apparent time intervals are not constant. One day may be longer than another. Two reasons for this irregularity are the earth's ecliptical orbit and the non-uniform angular velocity of the apparent sun's motion.

To master these problems, astronomers have created mean solar or standard time. A mean solar day is equal to an apparent solar day of average length. The difference between mean time and apparent time is known as the "equation of time."

In order to avoid the confusion of differences in time within a particular region, time standardized zones have been introduced. Each time zone differs by one hour, decreasing westward from Greenwich, England. In Canada, they do not necessarily change at provincial boundaries. Therefore, consult a map or atlas for the correct zone. The local standard time within each zone is the local mean time at its centre.

The position of the sun as it crosses the sky each day, from east to west, is measured by two angles; azimuth and altitude. Azimuth is the angle measured along the horizon, clockwise through 360° from true north. Altitude is measured vertically from the horizon, to a point directly overhead at 90° .

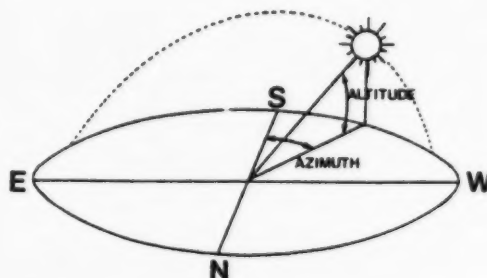


FIGURE 3: POSITION OF THE SUN

In the Ecocharts, three sets of azimuth and altitude angles representing the position of the sun at 9am, 12pm, and 3pm local standard time are provided for the 21st day of each month. All figures are given in degrees to two decimal places.

In order to calculate these angles for any other time, certain information must be known. Most of this information is easy to find or calculate. To save time and to improve accuracy, the use of an inexpensive solar ephemeris or almanac is recommended, such as:

The Star Almanac for Land Surveyors

H.M. Nautical Almanac Office - London, England.

The Nautical Almanac

Nautical Almanac Office

United States Naval Observatory - Washington, D.C.

K & E Solar Ephemeris

Keuffel and Esser Co., - Morristown, N.J.

FORMULAE

$$(1) \quad LT + DZ = UT$$

$$(2) \quad EQT = -7^m.65 \sin(0.9856N) + 0^m.50 \cos(0.9856N) \\ - 9^m.32 \sin(1.9712N) - 3^m.00 \cos(1.9712N)$$

$$(3) \quad UT + EQT + 12 \text{ hrs} - \lambda = LHA$$

$$(4) \quad \tan Az^\circ = \frac{\sin LHA}{\cos LHA \sin \phi - \tan \delta \cos \phi}$$

Note: Answer will be in the quadrant opposite to LHA.

$$(5) \quad \sin Al^\circ = \sin \phi \sin \delta + \cos \phi \cos \delta \cos LHA$$

NOTATION:

- LT - LOCAL (STANDARD) TIME - If local time used is during the daylight savings time period - the last Sunday in April to the last Sunday in October - then subtract one hour.
 DZ - TIME ZONE DIFFERENCE - Hours slower than Greenwich civil time (UT).
 UT - UNIVERSAL TIME
 EQT - EQUATION OF TIME can be computed for 1982 using equation(2). Its use for subsequent years will provide less accurate results. For higher accuracy use an ephemeris or almanac.
 m - MINUTE
 N - TIME - Number of days since 0 Jan. 0h UT.
 λ - LONGITUDE } Look up location on a map
 ϕ - LATITUDE }
 LHA - LOCAL HOUR ANGLE
 S - DECLINATION OF THE SUN - Given by an ephemeris or almanac, or, for a less accurate figure, steps 1 to 5 of the sunrise and sunset formulae can be used. (South is negative - north is positive).
 Al $^\circ$ - ALTITUDE
 Az $^\circ$ - AZIMUTH

Example - Azimuth and Altitude Angles for
 London, Ont. - Aug.21- 9a.m. LST.

$$N = 233 \text{ days}, \lambda = 81^\circ 14' W = 5^h.415, \phi = 42^\circ 59' N = 42^\circ.983$$

$$S = 12^\circ.106$$

$$(1) \quad UT = 9^h + 5^h = 14^h$$

$$(2) \quad EQT = -7.65 \sin(0.9856 \times 233) + 0.50 \cos(0.9856 \times 233) \\ - 9.32 \sin(1.9712 \times 233) - 3.00 \cos(1.9712 \times 233) \\ = -3^m.21 \text{ or } -0^h.053$$

$$(3) \quad LHA = 14^h + (-0.053) + 12^h - 5^h.415 = 20^h.532 = 307^\circ.98$$

$$(4) \quad \tan Az^\circ = \frac{\sin 307.98}{\cos 307.98 \sin 49.983 - \tan 12.106 \cos 42.983}$$

$$Az^\circ = -71.57 + 180^\circ = 108^\circ.43$$

$$(5) \quad \sin Al^\circ = \sin 42.983 \sin 12.106 + \cos 42.983 \cos 12.106 \cos 307.98$$

$$Az^\circ = 35^\circ.67$$

SUNRISE AND SUNSET

Sunrise and sunset times can give a rough idea of the maximum daylight hours possible on any given day for any location in Canada below 65° north latitude. Latitude and longitude must be known. The formulae below can be used for any date in the latter half of this century with an accuracy of ± 2 minutes.

The times given in the Ecocharts are shown in hours and minutes. Those values between the last Sunday in April and the last Sunday in October have been adjusted to Daylight Savings Time.

Formulae to Calculate Sunrise and Sunset

Notation:

ϕ	- Latitude (in decimal hours)	RA	- Right ascension of the sun
λ	- Longitude (in decimal hours)	δ	- Declination of the sun
t	- Approximate time in days	LHA	- Local hour angle
N	- Day of the year	T	- Local mean time
M	- Sun's mean anomaly	h	- Approximate hour of day
L	- Sun's true longitude	DZ	- Time zone difference

- (1) $t = N + (h + \lambda) / 24$
if sunrise $h = 6$, if sunset $h = 18$
- (2) $M = 0^\circ.985600t - 3^\circ.289$
- (3) $L = M + 1^\circ.916 \sin M + 0^\circ.020 \sin 2M + 282^\circ.634$
Note: If $L > 360^\circ$ then subtract 360°
- (4) $\tan RA = 0.91746 \tan L$
Note: change RA into hours by dividing by 15. RA must be in the same quadrant as L.
- (5) $\sin \delta = 0.39782 \sin L$
Note: to calculate $\cos \delta$ use the resulting δ from the above equation.
- (6) $\cos x = (\cos Z - \sin \delta \sin \phi) / (\cos \delta \cos \phi)$
Note: if sunrise $LHA = 360 - x$, if sunset $LHA = x$
change LHA into hours by dividing by 15
- (7) $T = LHA^h + RA^h - 0^h.065710t - 6^h.622$
- (8) $UT = T + \lambda$
- (9) Sunrise or Sunset (LST) = $UT - DZ$

If Daylight Savings Time is required, add 1 hour.

To convert hours and minutes to decimal hours - divide minutes by 60 and add to hours.

To convert decimal hours to hours and minutes - multiply decimals by 60.

Example - Sunrise May 21 Winnipeg, Manitoba

$$\phi = 49^{\circ}54'N = 49^{\circ}.9 \quad \lambda = 97^{\circ}14' = 6^h.4822 \text{ N} = 141 \text{ days } Z = 90^{\circ}50' = 90^{\circ}.83$$

$$(1) \quad t = 141 + (6 + 6.4822)/24 = 141^d.5201$$

$$(2) \quad M = (0.985600 \times 141.5201) - 3.289 = 136^{\circ}.1932$$

$$(3) \quad L = 136.19 + 1.916 \sin 136.19 + 0.02 \sin(2 \times 136.19) + 282.634 \\ = 420^{\circ}.1335 = 60^{\circ}.1335$$

$$(4) \quad \tan RA = 0.91746 \tan 60.1335 \\ RA = 57^{\circ}.9572 = 3^h.8638$$

$$(5) \quad \sin S = 0.39782 \sin 60.1335 \\ S = 20^{\circ}.1809$$

$$(6) \quad \cos x = \frac{(\cos 90.83 - \sin 20.1809 \sin 49.9)}{(\cos 20.1809 \cos 49.9)} \\ x = 117^{\circ}.4216 \\ LHA = 360 - 117.4216 = 242^{\circ}.5784/15 = 16^h.1719$$

$$(7) \quad T = 16.1719 + 3.8638 - (0.065710 \times 141.5201) - 6.622 \\ = 4^h.1144$$

$$(8) \quad UT = 4.1144 + 6.4822 = 10.5966 = 10^h35^m$$

$$(9) \quad \text{Sunrise local standard time} = 10:35 - 6^h = 4:35 \\ \text{Sunrise daylight savings time} = 4:35 + 1^h = 5:35 \text{ a.m.}$$

SHADOWS

Uninterrupted access to sunlight is a basic concern in the planning and design of solar collectors, buildings, roads, and landscaping. Shadows cast by the sun vary according to the sun's position, the height and shape of the structure, and the slope of the ground. A shadow can be calculated for any specific point in time. In order to ensure free access to sunlight all year, the largest possible shadow pattern should be calculated, for December 21st at winter solstice.

The values provided in the Ecocharts are shadow multipliers for level ground (see Equation 1). All values are calculated from altitude angles on the 21st of each month. The direction from which the shadow is cast is $\pm 180^\circ$ from the azimuth of the sun.

Formulae for Calculating Shadows

Notation:

- S - Shadow Length
- Az $^\circ$ - Azimuth
- Al $^\circ$ - Altitude
- H - Height of structure
- Sm - Shadow multiplier
- Sl - Actual shadow length
- Sp - Projected shadow length for a plan or map
- As $^\circ$ - Angle of slope
- $\tan As^\circ$ - Slope gradient = rise/run
- Azfl $^\circ$ - Slope azimuth of the fall line

Equation 1: Shadow Length for Level Ground

$$S = H \times Sm$$

where $Sm = \tan(90^\circ - Al^\circ)$

Equation 2: Formula for Actual Shadow Length on Sloped Ground

$$Sl = \frac{H}{\tan Al^\circ + (\sin As^\circ \times \cos(Az^\circ - Azfl^\circ))}$$

Equation 3: Protected Shadow Length for a Sloped Surface

$$Sp = \frac{H}{\tan Al^\circ + (\tan As^\circ \times \cos(Az^\circ - Azfl^\circ))}$$

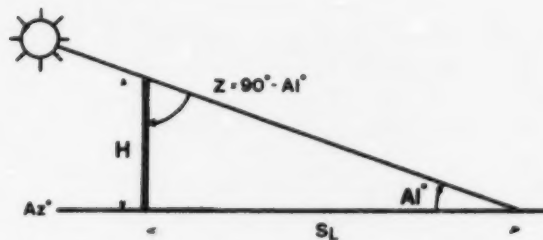


Figure 4 - Shadow length for level ground

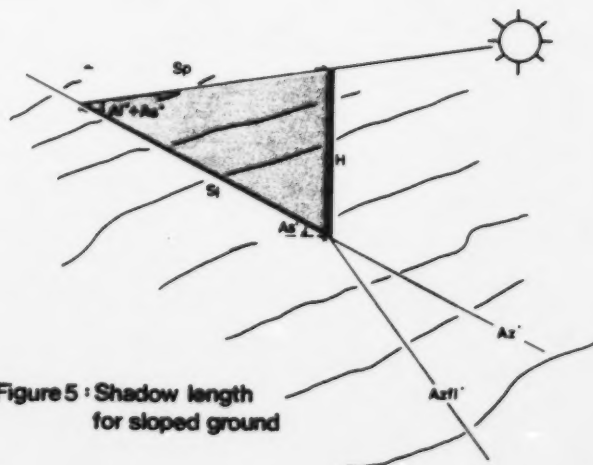


Figure 5 : Shadow length for sloped ground

Example 1 - Shadow on Level Ground

Regina, Saskatchewan - March 21, 9am L.S.T.

$$Az^\circ = 112^\circ.63$$

$$Al^\circ = 17^\circ.95$$

$$H = 12\text{m Pole}$$

$$\begin{aligned} Sm &= \tan(90^\circ - Al^\circ) & S &= H \times Sm \\ &= \tan(90^\circ - 17^\circ.95) & &= 12 \times 3.08 \\ &= 3.08 & &= 37.04\text{m} \end{aligned}$$

The azimuth of the sun is $112^\circ.63$
 the azimuth of the shadow is $292^\circ.63$.

Example 2 - Shadow Length for Sloped Surfaces

Halifax, Nova Scotia - September 21, 12pm L.S.T.

$$Az^\circ = 177^\circ.32 \quad Azfl = 135^\circ$$

$$Al^\circ = 45^\circ.98 \quad H = 15\text{m pole.}$$

$$As^\circ = 20^\circ.00$$

Actual Shadow Length:

$$\begin{aligned} Sa &= \frac{H}{\tan Al^\circ + (\sin As^\circ \times \cos(Az^\circ - Azfl^\circ))} \\ &= \frac{15}{\tan 45^\circ.98 + (\sin 20^\circ \times \cos(177^\circ.32 - 135^\circ))} \\ &= 11.65\text{m} \end{aligned}$$

$$\begin{aligned} Az^\circ \text{ of shadow} &= 177^\circ.32 \pm 180^\circ \\ &= 357^\circ.32 \end{aligned}$$

Projected Shadow Length:

$$\begin{aligned} Sp &= \frac{H}{\tan Al^\circ + (\tan As^\circ \times \cos(Az^\circ - Azfl^\circ))} \\ &= \frac{15}{\tan 45^\circ.98 + (\tan 20^\circ \times \cos(177^\circ.32 - 135^\circ))} \\ &= 9.64\text{m} \end{aligned}$$

Same shadow Azimuth of $357^\circ.32$

PLAN PROJECTED SHADOWS

A shadow pattern of any object or structure can be drawn for any point in time. The first step is to find the heights of the structure at its extremities (see figure 6). Then using equation 1, calculated the shadow lengths of the extreme heights. Finally, plot the shadow lines and connect the end points (see figure 7). Note that the azimuth of the shadow is exactly opposite to the azimuth of the sun.

For example, to find the shadow pattern for June 21st of a house situated on level ground in St. John's, Newfoundland, the following calculations must be made.

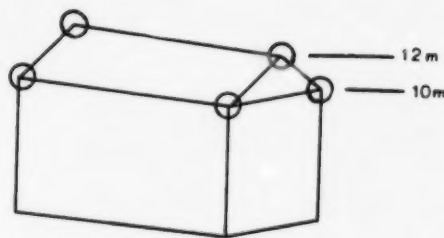


Figure 6 - Finding the extremities

	9am	12pm	3pm
Sun's Az°	107.36	178.56	251.41
Shadow Az°	302.87	357.32	53.55
Sun's Al°	46.59	65.87	47.41
Sm	0.95	0.45	0.92
H - 10 m	9.50	4.50	9.20
- 12 m	11.40	5.40	11.04

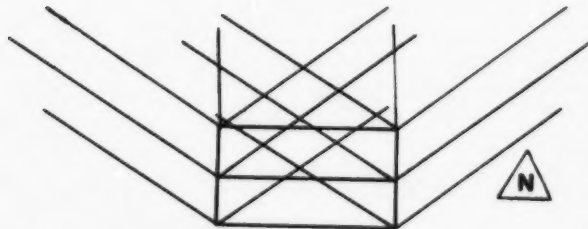


Figure 7 - Plan view

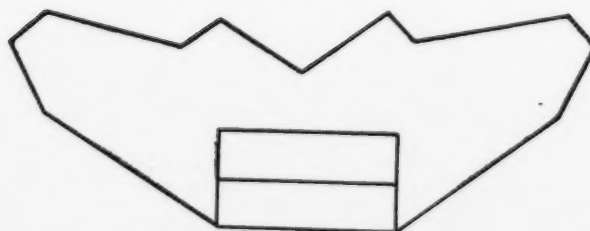


Figure 8 - SHADOW LENGTH

MEAN RAINFALL, MEAN SNOWFALL AND TOTAL PRECIPITATION

Precipitation greatly influences the meso-climatic environment. Total precipitation values given in each data chart are monthly totals of daily amounts averaged over a 30 year period (1951-1980). The annual value is the total of the 12 averaged monthly values.

Total precipitation is rainfall, plus the water equivalent of snowfall and all other forms of frozen precipitation. Mean rainfall and total precipitation are given in millimetres with mean snowfall in centimetres.

RELATIVE HUMIDITY

Humidity is an important factor in housing design and construction. Some humidity is necessary to obtain an acceptable level of comfort. An excess or lack of humidity can cause a variety of problems; mildew, water streaming from windows, static build-up, cracks in wood furniture, and sore throats.

Relative humidity is the ratio of the amount of water vapour present in a quantity of air, at a specific temperature, and is usually shown as a percentage. For example, 100 per cent humidity is air at a given temperature, containing all the water vapour it can hold. If the same sample of air contains only half of that maximum amount, then the relative humidity is 50 per cent. Temperature increases with no change in water vapour will result in a fall in relative humidity.

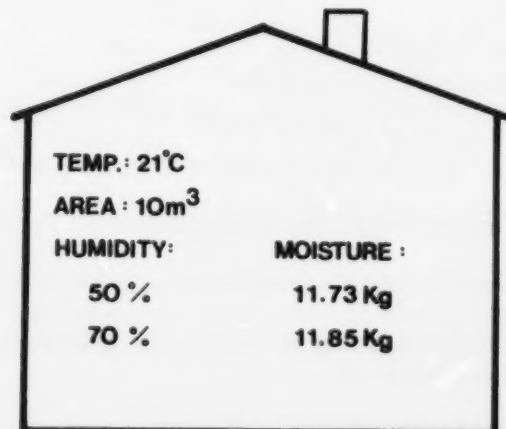


Figure 9 - moisture content
of air

AIR TEMPERATURE

The Canadian climate is characterized by large seasonal and regional changes in air temperature (see example below). A micro-climatic temperature pattern is one factor in determining local energy requirements.

Temperatures presented in the ecocharts are the mean values of recordings obtained over a 30 year period, 1951-1980. The annual figure is the mean of all monthly values. The unit of measurement is Degrees Celsius ($^{\circ}\text{C}$).

Example - Temperature changes

Location	Temperature ($^{\circ}\text{C}$)		Seasonal Variation
	Jan.	July	
Vancouver Int'l Airport	2.5	17.3	14.8
Regina Airport	-17.9	18.9	36.8
Regional Variation	20.4	1.6	

HEATING AND COOLING DEGREE DAYS

The concept of degree days is used frequently to establish energy consumption for heating and cooling in residential design work. A degree day is a measure, in degrees Celsius of the difference between the mean temperature for a day from a specific reference temperature. Heating degree days are based on a reference temperature of 18°C (64°F) and cooling degree days are based on 24°C (75°F).

Example:

Winter heating degree day	$18^{\circ} - (-10^{\circ})$	= 28
Summer cooling degree day	$27^{\circ} - 24^{\circ}$	= 3

PREVAILING WIND DIRECTION AND AVERAGE SPEED

The direction and speed of the wind can be both beneficial and detrimental to a building site. In summer, they are an important influence in promoting natural ventilation in housing. This cooling ability reduces the need for air conditioning. To avoid air infiltration aggravated by winter winds, insulation and sheltering from direct exposure is essential.

The prevailing wind direction shown in the Ecocharts is the wind direction with the highest monthly frequency. The average speed corresponds to the prevailing wind direction.

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